DOCUMENT RESUME

ED 370 567 IR 055 020

AUTHOR Myers, Robert J.; And Others
TITLE A Middle School's Experience with Hypermedia and Problem-Based Learning.
PUB DATE 93
NOTE 13p.; In: Visual Literacy in the Digital Age: Selected Readings from the Annual Conference of the International Visual Literacy Association (25th, Rochester, New York, October 13-17, 1993; see IR 055 055.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Databases; Educational Media; *Hypermedia; Junior High Schools; *Learning Strategies; Middle Schools; Models; Multimedia Instruction; *Problem Solving; Student Attitudes; Student Motivation
IDENTIFIERS *Multimedia Materials

ABSTRACT

This study examined whether the inquiry-based problem solving model supports sustained exploration of a multimedia database. This model contains five steps: (1) analyze the discrepant event from which a problem question is generated; (2) generate questions; (3) gather data; (4) analyze information; and (5) evaluate self. A group of 24 seventh graders were given a discrepant event about the Spaniards and the Aztecs and used a hypermedia database with the domain of Mesoamerican civilization. The desire to know appeared to be ignited by the discrepant event. Most students were engaged, motivated, displayed curiosity, and had fun. However, there might have been other contributing factors to student responses. As a result, it is not possible to conclude that the discrepant event inquiry approach provided motivation for sustained learning activities; however, it did appear to be at least one factor that led to a meaningful learning experience. (Contains 24 references.) (JLB)

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A Middle School's Experience with Hypermedia & Problem-Based Learning

by Robert Myers
Steven L. Purcell
Jamie O. Little
William E. Jaber

RM 202, War Memorial Hall
Virginia Tech
Blacksburg, VA 24061-0313

IR055090

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A Middle School's Experience with Hypermedia and Problem-Based Learning

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Are times changing? As of this writing, at least two states (Texas and California) have adopted curricular materials based on multimedia (A First, 1991). This has come about in part because newer hardware and software are both more powerful and less expensive. Mr. James Dezell (1993), President of EduQuest, says that multimedia is going to make core instructional software so compelling that our students are going to learn more. He also suggests multimedia will dramatically affect *how* students learn by creating new knowledge that demands application, promotes multiple points of view, engages active learners, eschews memorization, and is built with cultural tools.

For all of the excitement, however, many schools and teachers may move slowly in using multimedia systems. There are many reasons that may dissuade schools from employing multimedia. These include costs in terms of time, money, and lack of funding. In addition, few people have the combination of skills required to develop excellent (or even average) multimedia packages. Until recently most multimedia systems required two monitors, special interface cards, and an assortment of cables, players, and software. Until the prices of systems fall, and system requirements narrow to one standard unit, many schools may stay on the sidelines. Other extremely important issues that influence the adoption of multimedia are consideration of how teachers teach and how students learn. It is possible that the infusion of multimedia into the classroom will require abandoning traditional teaching paradigms.

Multimedia: Perils and Promise

One can encounter many definitions of the term

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multimedia. One definition includes a system that combines video, text, sound, animation, and graphics — all controlled by a computer. Hypermedia employs the same electronic forms as multimedia, but allows learners to access information in a nonsequential fashion. Critiques of hypermedia usage have mentioned difficulties in navigation and overloading of short-term memory (Conklin, 1987). Heller (1990) suggests that a lack of motivation or unfocused rambling may also occur.

The purpose of this study was to investigate methods that capitalize on the wealth of information in hypermedia databases, support sustained student learning activities, and occur in an atmosphere in which students learn significant skills in reflective thinking, and go beyond the input-recall state, into higher levels of thinking. We used an inquiry based problem solving model to create a context for sustained student activity. The model began with the introduction of a discrepant event. We focus on this issue.

Thinking Skills and Structured Inquiry

How do we get students to solve problems, think critically and creatively, make inferences, plan, hypothesize, generate independent solutions, and/or make decisions? These processes may need supporting activities such as "...defining situations, setting goals, formulating plans, comparing alternative courses of action, judging difficulty, apportioning time, and monitoring results" (Prawat, 1991, p. 4).

There is a wealth of literature on developing critical thinking skills, but the answer appears to be that we teach them (Resnick, 1987; Sternberg, 1984). Perkins (1986) suggests that we try to teach too much content to the neglect of those tactics needed to become better thinkers. In fact, Perkins avers that good thinking is an unnatural act. It is unnatural, he suggests, because, if left alone, human thinking tends to manifest three weaknesses: (1) taking egocentric approaches that incorporate biases, (2) suggesting problems before defining the problems, and (3) treating knowledge as information as opposed to knowledge as invention.

Prawat (1991) says that the most prominent technique of teaching thinking skills is to embed skills into the curriculum — or within the context of specific subject matter domains. This method blends an equal balance of thinking skills and subject matter. The importance of this approach is that learning and thinking are thought to result from an interaction between a learner and a situation rather than something occurring in a person's mind (Greeno, 1989).

Another useful way of creating a context for learning is through "situated cognition" (Brown, Collins & Duguid, 1989; Greeno, 1989). Brown, Collins, and Dugid contend that students need more than abstract concepts and canned examples. They suggest that learning should be conducted in activity situated in real-life social, cultural, and physical contexts. Research conducted by the Cognition and Technology Group at Vanderbilt (CTGV, 1990) is a good example of the use of media (videodisk) to "situate" or "anchor" students within a learning environment.

Having introduced the concept of embedding thinking skills within the context of subject matter, we now introduce an inquiry based problem solving model which is preceded by a discrepant event. The model is based on Piaget's (cited in Chapman, 1988) concept of disequilibrium and Festinger's (1957) concept of cognitive dissonance. Festinger (1957) suggested that individuals strive for internal consistency. When learners experience inconsistencies, psychological discomfort results. Festinger's theory provides us with this theory: "The existence of dissonance [inconsistency], being psychologically uncomfortable, will motivate the person to try to reduce the dissonance and achieve consonance [consistency]" (p. 3). Central to this argument is that introduction of new information may create cognitive elements that are dissonant with existing cognition. All that is needed is a means by which dissonance is created in learners.

Discrepant Events Within Inquiry

A spark is created with presentation of a puzzling situation or event. Nussbaum and Novick (1982) state that in order for accommodation of a new concept to occur, students must first recognize a problem as well as their inability to solve it. Students' inability is brought about by presentation of a "discrepant event." A discrepant event is simply an inexplicable condition, statement or situation. The discrepant event creates a state of disequilibrium (or cognitive dissonance as discussed above). The key in Nussbaum and Novick's argument is that once students are in a state of disequilibrium, they are motivated by "epistemic curiosity" (Berlyne, 1965) to reduce the disequilibrium. Nussbaum and Novick (1982) suggest that traditional instruction seldom provides for students to experience cognitive conflict.

Bruce and Bruce (1992) suggest that logic-defying problems often place us in a state of disequilibrium. Motivation from the disequilibrium causes *questioning*, *snooping*, and *searching* to reduce uncertainty and re-enter a state of equilibrium. Accordingly, Bruce and Bruce offer an inquiry model to take learners through five phases in their quest to reduce disequilibrium:

(1) Discrepant Event. Students read or are presented a discrepant event. From it, they generate a problem question. Discrepant events, or situations such as them, have received frequent attention in the social sciences. Costa (1991) states that the inquiry method purposely creates situations to extend reflective thinking. Massialas, Sprague, & Hurst (1975) offer several devices to get students' attention and involvement. Their suggestion is to use "springboards." Springboards can take such forms as documents, magazine articles, graphs, and visual media. They cite a multimedia unit entitled *World History Through Inquiry* that draws from several disciplines to get students to examine and discuss issues. Massialas et al. also suggest using "puzzling documents" that lack critical facts and conclusions or include discrepancies.

(2) Generate Questions. Students create a series of questions that can be answered with a "yes or no" response. Making them create a yes or no question causes students to organize their thoughts. This way the learners are probing for specific information instead of general, subsuming types of questions.

(3) Gather Data. Students gather data to answer questions about important variables and ask hypothetical and causal questions.

(4) Analyze Information. Students analyze their information to reach a hypothesis.

(5) Self Evaluation. Last, in a metacognitive mode, students review the entire process.

Hypermedia Data Base

We developed a hypermedia data base incorporating scanned color images, graphics, text, and audio. The domain for the prototype was the ancient Mesoamerican civilizations. The original focus was the Aztec Empire. As the project developed however, the data base expanded to include brief references to other peoples such as the Mayas, Incas, and Olmecs. This topic was excellent for a seventh grade social studies class. Because most sources about ancient Mesoamerica are post-Colombian, there are a variety of conflicting opinions, interpretations, and thoughts about the subject matter. These result from the Spanish destruction of nearly all pre-Colombian recorded history. What we know about these cultures was recorded by monks and Indian chroniclers after the conquest. This background provided a context-rich environment for higher-order thinking, especially in a social studies class.

Note. From "That fateful moment when two civilizations came face to face" by C. L. Mee Jr., 1992, *Smithsonian*, 23,7, p. 69. Copyright 1992 by Smithsonian Institution. Reprinted by permission.

The thematic hypermedia data base was developed around people, deities, places, things, and events. Our research began with the story of Cortés and the end of the Aztec Empire. It then expanded into the life and practices of Aztecs. Practices included their commerce, relations with neighbors, agriculture, art, architecture, and especially their proclivity for human sacrifice and cannibalism. As the research continued, it seemed natural to provide a background concerning the changing world during the "Age of Exploration" (the 16th century). It also seemed appropriate to expand into the other Mesoamerican peoples because of questions concerning the origin of all people native to the Americas.

Below Is a Scenario Encountered by Students

I. Discrepant Event. In 1519 Cortés, a Spanish sea captain with 550 men (including 32 crossbowmen, and 13 musketeers) and 16 horses, landed on the Yucatan Peninsula. This was the area of the Aztec, an empire that stretched from central Mexico to the present boundary of Guatemala. Within this area were 25 million people governed by Montezuma. Montezuma's capital city of Tenochtitlán quartered some 50,000 Aztec warriors. Within two years, however, Montezuma would be dead, Tenochtitlán would be in ruins, the empire would be in chaotic disarray, and the Spanish would control the area.

Students, assisted by problem solving steps, would generate a problem statement. Massialas, Sprague, and Hurst (1975) suggest asking questions to generate the problem definition. Such questions might include:

- What is this story really about? One possible answer might suggest that disaster struck millions of people when the complexities of cultures, societies, and technology clashed.
- What is the nature of the problem, or did anything unusual happen? A possible answer is: It doesn't make sense that a few men in ships could make a whole empire fall.

Based on an analysis of the event, an typical problem statement might be: How could such a small force of Spaniards cause such profound changes in the Aztec culture in such a short time? With that, the students are able to begin solving the problem.

II. Generating Questions. The inquiry model provided in the software now suggests students produce questions that can be answered with a yes or no response. Here are appropriate examples:

- Were the Spaniards' weapons superior to the Aztecs'?
- Is it possible that there were fewer Aztecs than originally thought?

- Did religious beliefs affect the outcome?
- Did Spaniards bring some type of disease?
- Did Spaniards have a superior form of warfare?

III. Gather Data. Using the hypermedia data base, plus other references, students search for answers to their "yes or no" questions. At the end of this step, they are closer to hypothesizing causes of the discrepant event. Students are not left on their own to wander aimlessly about hyperspace in search of answers. The system contains guides to offer suggestions about the most likely place to search; there is also a "Journal" for record keeping.

IV. Analyze Information. Students are now in a position to

analyze the data and generate a hypothesis or hypotheses. In this particular case, their hypothesis might take this form: Cortés was extremely lucky; he took advantage of Aztecs' superstitions and religious beliefs which indicated he and his men were gods. He was fortunate to find Donna Marina, a native who quickly learned the Spanish language. Cortés also enlisted the aid of thousands of

Note. From *The Course of Mexican History*, (p. 127) by M .C. Meyer & W. L. Sherman, 1987, New York: Oxford University Press. Copyright 1987 by Oxford University Press. Reprinted by permission.

local Indians who were glad to find a way to overthrow Montezuma. The Spaniards' weapons were especially effective against the Aztecs who were not used to "total warfare." The Indians were terrified of armored soldiers mounted on horseback. The Aztecs suffered grievously from diseases brought by Spaniards. And last, the city of Tenochtitlán was easy to blockade and starve into submission.

V. Self Evaluation. Following the inquiry based problem solving model, students now evaluate their problem solving strategies. Bruce and Bruce (1992) suggest that developing evaluative skills improves thinking and questioning during future problem solving situations — hence, providing for skill transfer. Here is a list of appropriate evaluative questions provided by Fontana, White and Cates (1992, p. 12):

1) Is the data relevant or necessary to proving or disproving the hypothesis?
2) Has sufficient data been collected?
3) What is the source of each piece of data? Is the source credible? Is it reliable?

4) Does any piece of data incorporate bias or narrow points of view?
5) Does each piece of data make a persuasive and logical argument?
6) Are stereotypes represented?

Purpose and Rationale

This study looked at the following question: Does the inquiry based problem solving model support sustained exploration of a multimedia data base?

Method

An extant seventh-grade class of 24 students served as participants during the week-long study. Students were divided into four groups of six. Assignment of students was not random, so results of this study may not generalize to others of the same age and background. Groups were formed by the teacher before arrival of the observers. Although ability tracking had been discontinued in this particular middle school, this class was chosen by the teacher because she thought there would be the closest match between proposed methods and the personality of the class. Students were assigned the roles of leader, researcher, computer operator, and recorder.

Means of gathering data consisted of direct observation, videotape, audiotape, post-exercise questionnaires, and evaluation of students' products. Each group had a research assistant who served as both a facilitator and evaluator. Researchers used a model by Massialas, Sprague, and Hurst (1975) to analyze students' engagement. Here are the objectives provided by Massialas et al. pertaining to the research question:

1) Showing interest. Students are willing to give their attention or have a positive attitude in using the system to resolve discrepant events. Students' attitudes or interest may be observed in some of the following ways: "listening, being excited about something, coming up after class to talk about the issues" (Massialas et al., 1975, p. 149).

2) Showing involvement. Students go beyond the level of just showing interest. They commit themselves to an activity by using their own initiative to participate.

Results

Nearly all indicators, facilitator observations, videotape, audiotape, teacher observations, and student questionnaires, indicated students were motivated and engaged in sustained activity. Students came into the classroom and began work without being told to do so. Work continued until the very last second, then students hurriedly grabbed their belongings (as if they were about to late) and left for the next class.

Students' desire to know appeared to be ignited from the discrepant event. Just as the

literature indicated, it seemed the discrepant event served as a springboard to sustained activity. One student in the pilot study said the problem solving sequence was "fun and exciting, just like solving a mystery." This doesn't mean that the problem solving model was followed to perfection. The students, however, were heavily engaged in the problem solving process as soon as they received the discrepant event. The facilitator from Group 2 commented that her students were motivated and never lost interest or seemed bored. Group 2's facilitator also reported that her group was so proud of their work that they asked over and over if they could share their results with the others. Behavioral problems did not exist, and the group wanted to get through the problem so they could get into another.

The teacher reported that this whole approach exposed students to new worlds of thought and approaches to learning. In her opinion, the discrepant event approach got the students so involved that they wanted to both continue the exercise and share notes with each other after this study was over. The teacher reported that the students were just "full of themselves." By this, she meant that the students were fully absorbed in the puzzling situation and wanted to keep working at refining their hypotheses. She said they bounced ideas off of each other outside of class. During the week after the exercise, they still wanted to share information with the rest of the class.

In Group 4 there was one exception to the generally excellent use of the discrepant event. The facilitator had a particularly difficult time in getting this group to confront the discrepant event and develop a problem statement. This difficulty appeared to arise from the selection of a group leader who maintained that he knew the answers and did not need to pursue the matter. Whether the recalcitrant student had a history of being combative, or whether the discrepant event was not challenging enough is unknown. The discrepant events certainly appeared to be challenging and perplexing to the other groups. The teacher did say that Group 4 was composed of particularly strong personalities. This group leader's preconceptions evoked thoughts of Gardner's (1991) suggestion that educators have no idea how pervasive and strong are initial conceptions, stereotypes, and scripts that students bring to the classroom. Gardner maintains these preconceptions are difficult to refashion or eradicate.

Discussion

With the exception of Group 4's initial difficulty, the students were engaged, motivated, displayed curiosity, and had fun. It would be fair to question, however, whether there were other contributing factors to students' active engagement. For example, the novelty effect may certainly have

played some role. This particular section of students may have experienced the "Hawthorne Effect" from being picked to participate in this study. The classroom had been rearranged, and students were told they would be participating in a study. Four color computers, four audio recorders, one video recorder, and four researchers were present to record students' actions. Students were placed into groups and assigned roles (an exception to common practice). They were then given paradoxical statements about people who lived over 400 years ago. These people were known to be fierce and warlike. They sacrificed thousands of individuals at a time and ate some or all of the remains (depending upon whom one believes). The exercise was to last only one week and it was to be presented by methods the students had never seen. It is also possible that events occurring in the classroom before we arrived contributed to the observed results. That is, the history of this teacher's interactions and pre-study comments to the class were unknown. Last, the students were probably aware that Aztecs and Maya were their teacher's favorite subject and that she expected them to think and devote their energies to this study. All of these variables may have contributed to the students' interest and motivation.

Another way of looking at the discrepant event inquiry model would be under the umbrella of "anchored instruction" or "situated cognition" (Brown, Collins, & Duguid, 1989; CTGV, 1990). Using the discrepant event, students were introduced to a context that had meaning, a purpose, and a direction for engaged activity. As soon as the "Puzzle" was read, students had the context of a specific subject matter domain. Their observed behavior indicated continuous, purposeful pursuit until resolution of the discrepant event. They researched, took notes, hypothesized, then supported their hypotheses in open discussion. They then eagerly anticipated, and in fact asked for, permission to engage in the next discrepant event.

Can we state that the discrepant event inquiry approach provided motivation for sustained learning activities? No. Many students appeared to view the reading of the discrepant event as the beginning of an adventure and the data gathered in this study seemed to support the literature. Specific contributing factors to motivation, however, were difficult to identify. The facilitators and the teacher were encouraged from using the inquiry based problem solving model, but generalizing the success in this study to other classrooms and situations would be inappropriate.

Implications for Education

The goal was to create a functional system in a classroom that included a facilitative teacher, energized students, a hypermedia data base dealing with Mesoamerican Indians, additional

subject matter resources, and methodology designed to sustain student task engagement. In many respects, this goal was reached. Students were involved throughout the week in learning a problem solving model (process) and Mesoamerican history (content). Although we could not narrow student interest, motivation, or activity to a specific factor, the inquiry (problem solving) model preceded by a discrepant event appears to at least be among the factors contributing to a meaningful learning experience. While this study was narrowly focused, we envision using this scenario for interdisciplinary studies. We could easily have involved the disciplines of English, science, geography, social studies, history, and math in the content of the exercise. We are optimistic that this approach offers both opportunities for further research, and a means of facilitating integration of technology into the classroom.

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